How to Build a Pedal-Powered Cell Phone Charger

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Glossary

AC (alternating current) - a type of current that switches directions, i.e. *alternates* direction of flow. This is the type of current that we use in our homes (Nondestructive Testing [NDT] Education Resource Center, 2012a).

alternator - an alternator is a special type of generator used in motor vehicles. It converts kinetic energy (which turns a shaft) into electrical energy - specifically alternating current (hence its name). Advantages of an alternator are that it contains diodes which convert the AC to DC (for charging a battery) and that it usually has a built-in voltage regulator (to make sure that the voltage remains at a consistent level) (Conjecture Corporation, 2014a).

capacitor - A capacitor consists of two conducting plates with a non-conducting material in between. A capacitor can store energy, similar to a battery (Brain & Bryant, 2014). In the case of a bicycle generator, the role of a capacitor is to smooth out the pulses of DC (converted from AC) before it goes into the voltage regulator. If you are storing the energy in a battery rather than charging an electronic device directly, then a capacitor may not be necessary.

DC (direct current) - a type of current that flows in one direction only (as opposed to alternating current). Direct current is needed to charge a battery and is the type of current which is output by a battery (NDT, 2012b).

digital multimeter - A digital multimeter is a tool which measures three types of current: amps, volts, and ohms (Conjecture Corporation, 2014b). My first use of a multimeter was to find out if my used bike generator was functional and to find out if it produced AC or DC.

diode - A diode allows current to flow in one direction, but resists flow in the other; therefore, it can be used in a rectifier to convert AC to DC (Diode, n. d.). This is important when the current generated is AC, but DC is needed for charging a battery.

generator - In a generator, mechanical energy (from bicycle pedals, for example) turns a shaft which in turn causes a coil to rotate within a magnetic field. The rotation of the coil in the magnetic field causes a current to flow (California Energy Commission, 2012).

motor - A motor works oppositely to a generator. Current is fed into the coil which is within a magnetic field. This produces a magnetic force perpendicular to the magnetic field, so the coils rotate. The rotation turns the shaft which can then do work (Nave, 2012a).

Ohm's law - $I = V/R$ can be solved for V to yield $V = IR$ or Voltage (in volts) = Current (in amps) x Resistance (in ohms) This formula can be combined with a form of Joule's Law: $P = I^2 R$. Combining these equations produces the formula: $P = VI$. This allows us to calculate the amount of power generated (Nave, 2012b; Joule's Law, 2014).

rectifier - A rectifier uses one or more diodes to convert AC to DC (All About Circuits, 2012).

voltage regulator - A voltage regulator does exactly what it says - it prevents the voltage from fluctuating wildly and maintains it within safe/useful boundaries (Voltage Regulator, 2014).

Introduction

This manual provides instructions for building a pedal-powered generator (PedGen1) to be used for charging cell phones or other similar devices. The story of how PedGen1 was developed can be found at www.pedgen.weebly.com. I chose to use a treadmill motor as the generator for this project after seeing the *Make a Bicycle Generator* website (Do It Yourself World, 2013). However, one could experiment with different types of motors. The generator can be used to charge a device or to charge a 12-volt battery. Suggestions for both options are included in Step 5 of the manual.

Materials List

an old bicycle with bike/axle pegs (1 ½ inches in diameter)

treadmill motor

wood (we used 3 two-by-fours)

or metal (if you have welding skills) out of which to build a stand for the bicycle

a serpentine belt (we used a K060725 6-rib, 73 ¼ inches outside length)

screws (if using wood to build the stand)

4 bolts (to securely anchor the generator)

18 gauge wire

cigarette lighter receptacle

voltage regulator (12-volt or variable)

inverter

12-volt battery (optional)

cell phone charger

electrical tape (optional)

assortment of solderless wire terminals and connectors

Tools List

drill

socket set and/or Allen wrenches (for dismantling the bicycle)

digital multimeter

crimp tool wire stripper

pliers

Procedure

Step 1: Bicycle Preparation

Figure 1 shows the bicycle before major modifications were made. Remove excess parts of the bicycle as shown in Figure 2. You will need various tools including a socket set, pliers, and Allen wrenches. Remove the handle bars, front tire, brakes, kick stand, and seat. In Figure 2, the rear wheel was also removed so it could be replaced with a wheel that had longer bolts to allow axle pegs to be screwed on. If your bicycle already has long enough bolts for attaching pegs, then leave the wheel on but remove the tire. Screw on the axle pegs.

Figure 1: bicycle before major alterations

(handle bars were removed so that bike would fit in the trunk of a car)

Figure 2: bicycle after excess parts had been removed

Step 2: Construction of the Bicycle Stand

The stand used in this project is built out of two-by-fours and was inspired by the stand used in the project *Make a Bicycle Generator* (Do It Yourself World, 2013). If you have welding skills, you could make a similar stand out of metal. First, decide how wide to make the stand. The base piece of wood used in the stand pictured in Figure 3 is 36 inches long and is turned on its side. Once you have decided on the length of your base board, cut a piece of two-by-four the appropriate length. Next, decide how high you need to lift the axle pegs in order to keep the wheel from touching the base board. In Figure 3, the pegs are supported by a 10-inch piece of wood with 15-inch pieces on either side. Cut all six pieces of wood for the peg supports (four 15-

inch pieces and two 10-inch pieces). The shorter pieces should sit on top of the base board while the 15-inch pieces touch the floor and are attached on either side of the base board. Use 2-3 inch screws for attaching the two-by-fours as shown in Figures 4 and 5. I recommend pre-drilling the holes before inserting the screws.

Figure 3: building the peg holders

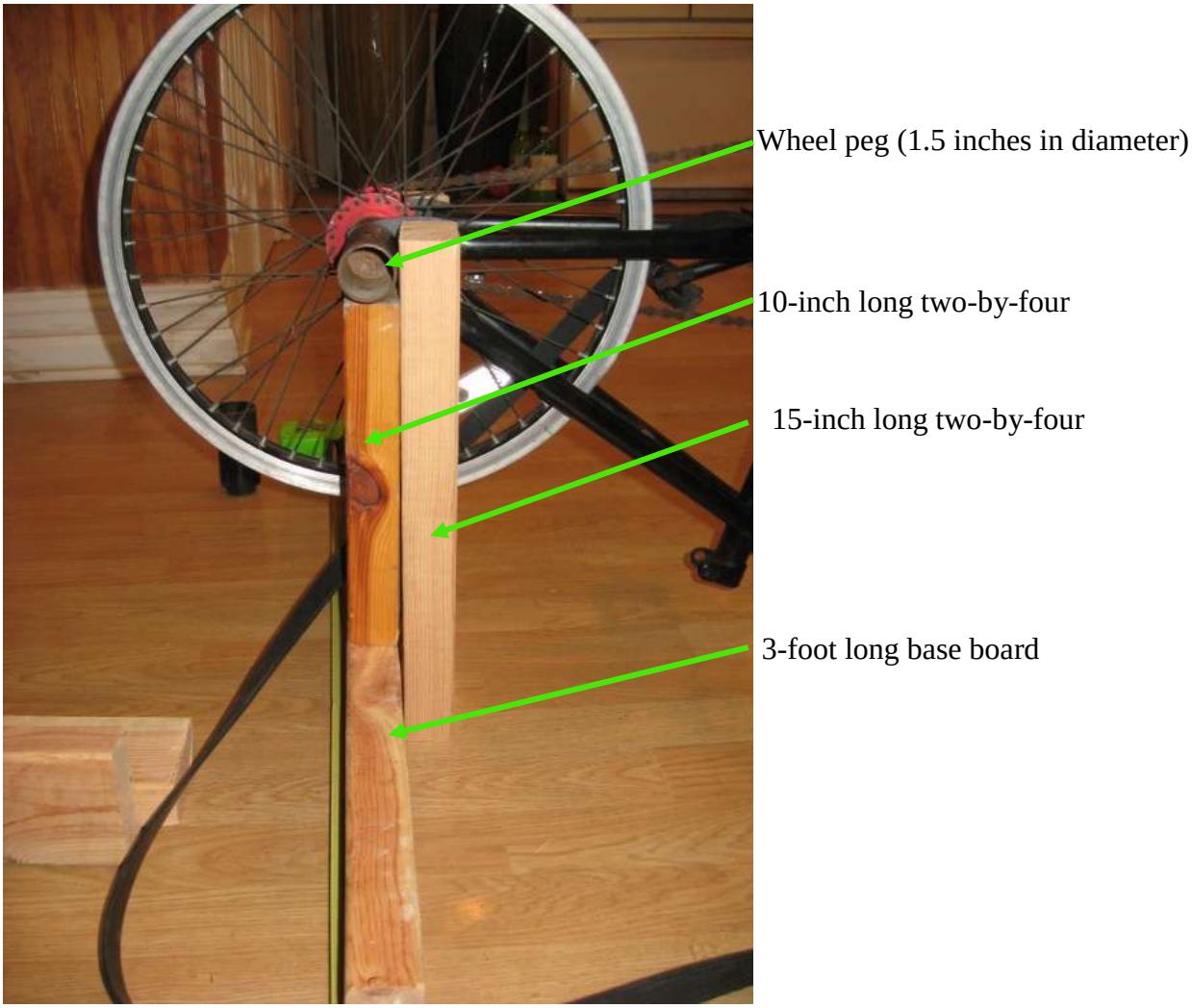


Figure 4: looking down on the base board and peg holders

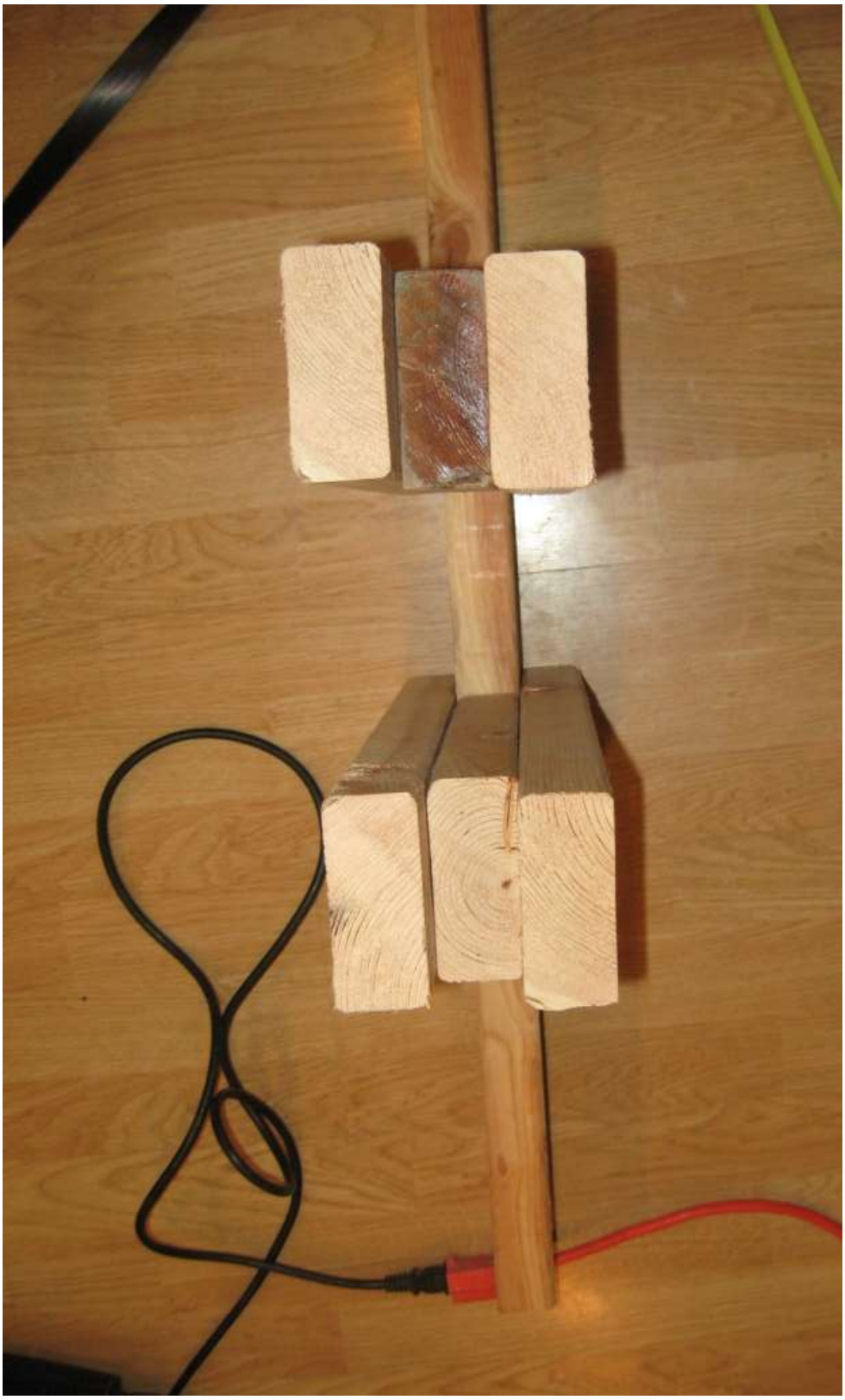


Figure 5: front view of base board and peg holders

Figure 6 shows the generator platform. In this design, we used three pieces of two-by-four set on their side. The piece on the left in Figure 6 is 24 inches long while the two shorter pieces are 22 ½ inches long. If you happen to have a longer serpentine belt, your platform will need to be longer. Cut three pieces of two-by-four for the platform (one 24-inch length and two 22 ½ -inch lengths). These three boards can be attached to the base board by inserting screws at an angle. A screw can be inserted from the front side of the base board into the longest platform board. Then, screw the three boards together with two or three screws from each side.

In order to align the generator shaft with the bicycle wheel, we raised the generator up on two blocks - each 5 inches in length and screwed side-by-side to the three long boards. Cut two 5-inch two-by-four blocks and attach them as shown in Figure 6. The distance between the blocks and the peg holders will be determined by the length of the serpentine belt. In our design, the block farthest away from the bicycle was attached 2 inches from the end of the platform. Figure 7 shows the completed bicycle stand.

Figure 6: attaching the generator platform

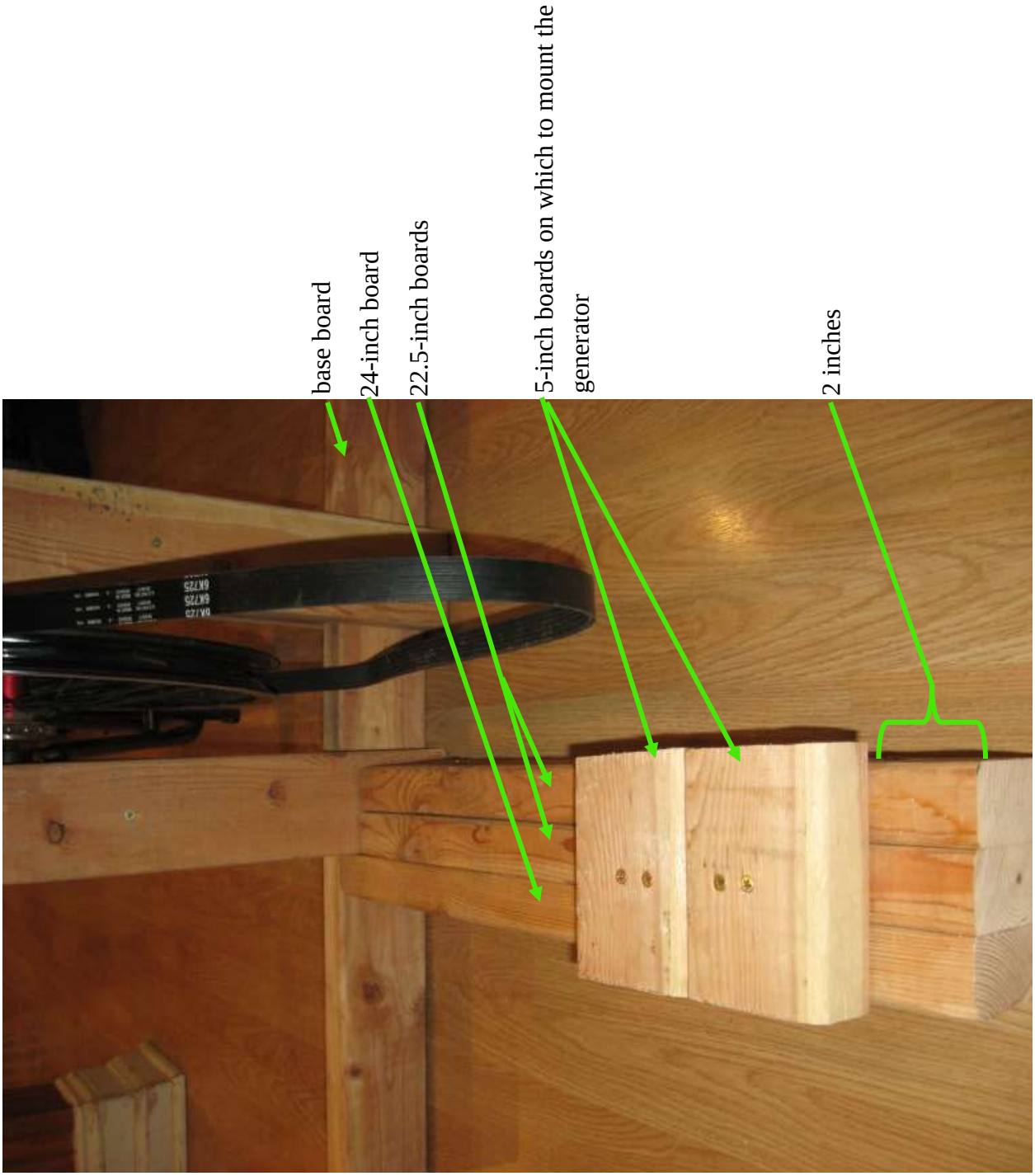
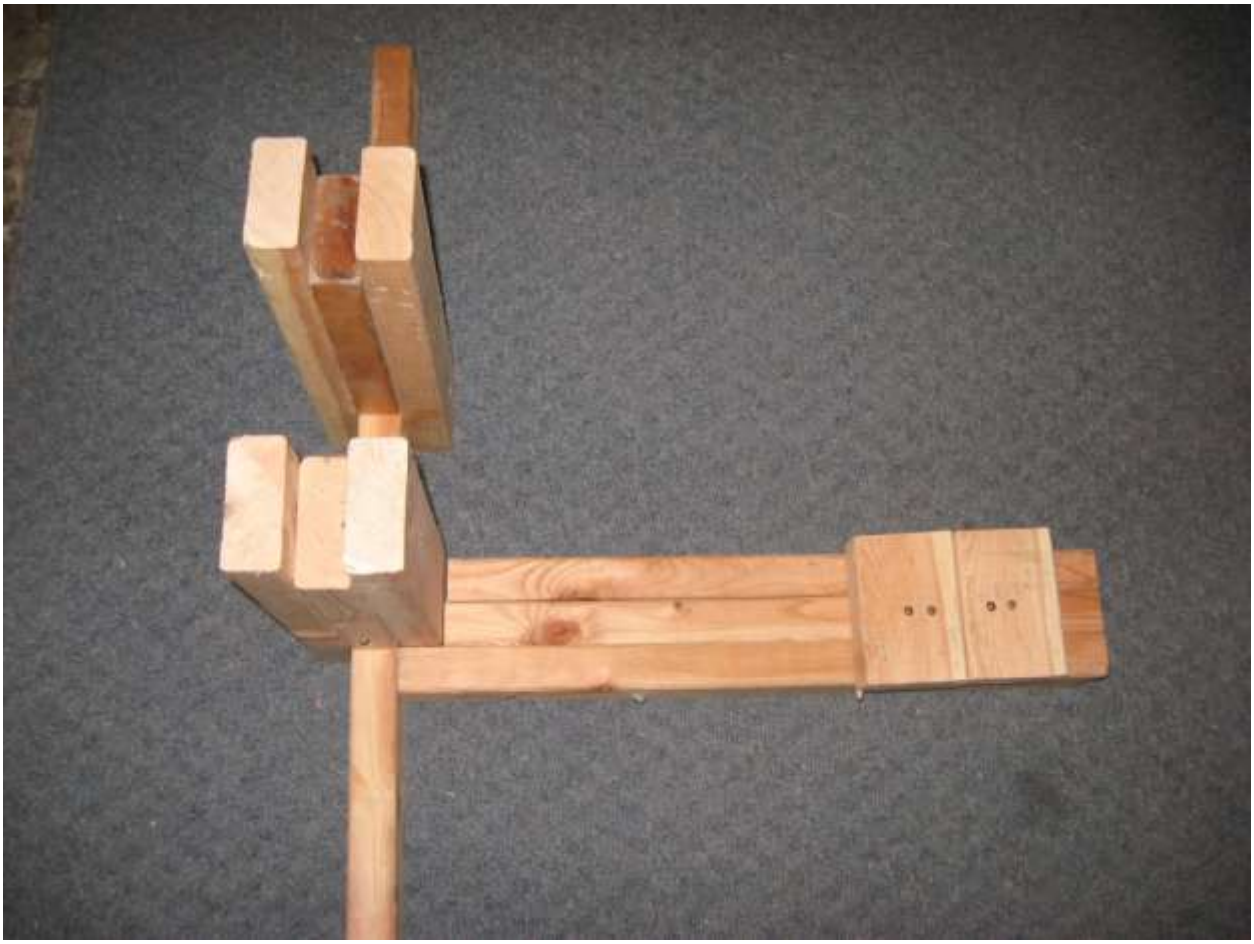


Figure 7: the completed bicycle stand



Step 3: Attachment of the Generator

To anchor the generator you will need to remove the tire from the wheel if you have not already done so. When we did this, the rubber strip covering the spoke screws fell apart. To protect the belt from the spoke screws, I wrapped the wheel with electrical tape as shown in Figure 8. I used one entire roll of electrical tape.

Figure 8: wrapping the wheel with electrical tape

Once the wheel is prepared and attached, set the bicycle in the stand you have just constructed. Position the serpentine belt on the wheel and pull it toward the generator platform. Place the generator on its platform and loop the belt over the generator shaft. Use a square to align the wheel and the generator shaft. Bolting down the generator requires two people or clamps. The generator must be pulled away from the bicycle to put tension on the belt. While the generator is held in place, use a pencil to mark where the holes need to be drilled. Pre-drill the holes. Insert four bolts to attach the generator to its platform as seen in Figures 9 and 10.

Figure 9: attaching the generator

Figure 10: the generator bolted to its platform

Once you have the generator attached to the bicycle stand, turn the pedals and observe the belt. If the belt slides off the edge of the generator shaft, you will need to attach a stop of some sort. You can weld a disc to the end of the shaft or use a strong adhesive compound (such as JB Weld) to affix a disc. I used JB Weld to affix a metal lid from a jar of peanut butter, as shown in Figure 11.

Figure 11: the jar lid to prevent the belt from sliding off the generator shaft

Step 4: Test Your Generator

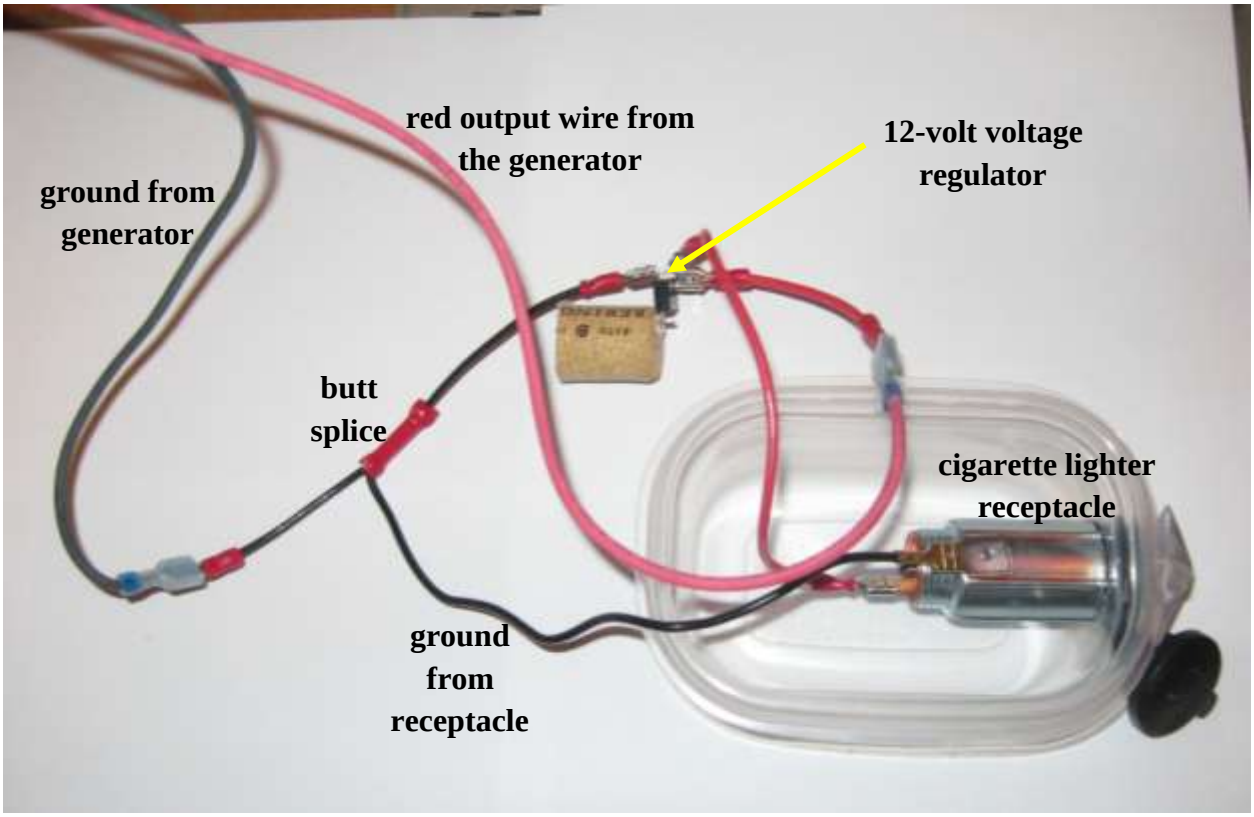
Once you have the bicycle situated in its stand and the generator is attached, loop the belt over the bicycle wheel and the generator shaft. Then attach a digital multimeter to the red and black wires of the generator, following the multimeter instructions for measuring voltage. Experiment with pedaling at different rates and observe the voltage. Using PedGen1, I found that leisurely pedaling by an adult yielded about 25 volts. It is advisable to add a clamp-on ammeter to this same circuit in order to measure the current through the circuit. My current was 0.7-0.8 amps. Whether you intend to simply connect a 12-volt cigarette lighter receptacle or a 12-volt battery to the generator, you will have to step down the voltage. 25 volts is too high a voltage for charging a 12-volt battery. According to the owner of Interstate Battery in Wichita, KS (M. Primm, personal communication, April 9, 2014) 13.5 to 14.5 volts are required for charging a 12-volt battery.

Step 5a: Completion of the Circuit Without a Battery

If you prefer to charge only while pedaling, a battery is unnecessary. You can create a simple circuit consisting of a 12-volt voltage regulator and a cigarette lighter receptacle. Because the generator produces direct current, you will need to plug an inverter, like the one in Figure 12, into the lighter receptacle. Then items can be charged from the inverter. The regulator and the receptacle can be mounted inside a small plastic "project box." These can be purchased from an electronics store or can be improvised with a plastic food storage container. For precise wire connections, soldering is advised. However, Figure 13 shows how the circuit can be constructed using solderless terminals and connectors.

Figure 12: inverter

Figure 13: an example of wiring a voltage regulator and cigarette lighter receptacle



The voltage regulator has three prongs. For ease of working with and positioning the voltage regulator, I attached it to a piece of cork using two straight pins. When the lettering on the regulator is facing you and the prongs are pointing down, the left prong is the input prong to which you attach the red wire from the generator (Learning About Electronics, n. d.). Bend the middle prong backwards to make it more accessible. This is the ground prong (Learning About Electronics, n. d.). The ground wire from the generator and the ground wire from the cigarette lighter receptacle must be spliced together (I used a butt splice) with a single short ground wire to form a Y. Connect the single ground wire (the tail of the Y) to the middle prong of the voltage regulator. Finally, connect the prong on the right to the center tab on the cigarette lighter receptacle using a red wire. Your circuit is then complete. You will have to monitor the voltage regulator for signs of overheating. It may be necessary to add a heat sink.

Step 5b: Completion of the Circuit With a Battery

If you choose to charge a 12-volt battery, you will need an input voltage of approximately 14.2 volts. In order to step down the voltage from the generator, you need to incorporate a variable regulator. I used the Velleman 1A Power Supply Kit K1823 pictured in Figure 14. The kit may be purchased from an electronics store or online and will require some assembly, including soldering. Assemble the power supply kit using the instructions included with the kit. Then connect the generator and the battery to the variable voltage regulator. You will have to pedal your generator and adjust the regulator output to 14.2 volts. The final step is to connect the cigarette lighter receptacle to the battery so that you will be able to plug in an inverter. I recommend putting the variable voltage regulator and the receptacle in a project box to protect them from dust and dirt. To prevent overcharging the battery, you should monitor the charge in the battery using a voltmeter or a charge controller.

Figure 14: Velleman 1A Power Supply Kit

Now you are ready to enjoy your off-the-grid pedal powered charger!

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Generator Bicycle http://makezine.com/projects/generator-bicycle/

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